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SUBJECT: Transmittal of the Proposed Modeling Approach for the Central Facilities Area Landfill Covers – (FMDP-FFA/CO-04-078)

Dear Mr. Ceto and Mr. Koch:

One of the recommendations in the Central Facilities Area (CFA) annual monitoring report was to evaluate infiltration through the landfill covers by using a numerical model. This letter summarizes the proposed modeling approach.

The CFA landfill cover was designed using the Hydrologic Evaluation of Landfill Performance (HELP) model to reduce infiltration through the CFA landfills and limit the advective transport of contaminants from the wastes to the underlying aquifer. Since the design of the CFA landfill covers was completed, questions have arisen about the use of the HELP model to evaluate landfill covers in arid climates. In order to evaluate whether the CFA landfill covers are performing as intended, a numerical modeling study will be conducted that will complement the existing soil moisture monitoring program. The modeling objectives are to determine the rate of infiltration through the landfill cover under existing conditions, and examine how that flux might change in response to a limited set of hypothetical changes in climatic conditions and/or vegetative cover. To accomplish these objectives, the modeling study will consist of the following subtasks.

1. Review existing data describing the landfill, its cover design, and as-built construction
2. Collect data for evapotranspiration and water infiltration modeling
   a. Obtain and organize long-term meteorological data records from the CFA weather station
   b. Format meteorological data for model input for HYDRUS-1D
   c. Develop a model of the cover stratigraphy
   d. Estimate hydraulic properties of cover material from available data

3. Simulate infiltration flux under modern climatic conditions and existing physical conditions using a 30+yr time frame to determine the water flux that would penetrate the landfill under existing climatic conditions
4. Compare simulated flux to appropriate time-domain reflectrometry and neutron access probe measurements of moisture content
5. Calibrate infiltration model to existing soil moisture content monitoring data, if appropriate
6. Perform simple sensitivity analysis to estimate uncertainty in calculated infiltration rates
7. Examine sensitivity of net infiltration to a limited set of hypothetical changes in physical and climatic conditions, for example:
    a. Increases in precipitation and temperature consistent with current predictions for climate change in the Pacific Northwest
    b. Changes in vegetative cover that may improve or reduce the evapotranspirative capacity of the cover.

For numerical modeling, we will use the HYDRUS-1D code, which incorporates the necessary moisture transport and evapotranspiration functions and also has a graphical user interface that simplifies changes to the input parameters necessary for the anticipated numerical experiments. The HYDRUS simulator calculates surface water balance based on a potential evapotranspiration flux that is calculated from time-dependent meteorology input records. This approach assumes that the energy balance that controls water removal is largely unaffected by heat transfer into the soil, so that the potential for evapotranspiration from the surface can be calculated from the rate at which energy is supplied. If the meteorological data suggest that heat transfer within the soil column may have a significant effect on surface energy balance, then additional simulations using an energy balance approach will be conducted using the UNSAT-H v3 code.

The first task (subtasks 1 through 5) is to develop a model of the landfill cover to simulate soil moisture infiltration through the cover using a 30+yr time frame to determine the water flux that would penetrate the landfill under existing climatic conditions and to compare simulated water content data to monitoring data. This task includes the development of a long-term meteorological database for calculation of potential evapotranspiration. This database will use data from the CFA weather station, supplemented with data from other nearby stations where necessary. Vegetation characteristics, including root distribution, maximum transpiration rate, and phenology will be derived from a combination of literature values and, if possible, in-situ measurements. Subsurface stratigraphy and hydraulic properties will be based on landfill construction design parameters and observations of cover conditions. After developing the basic model, we will compare results with moisture content monitoring data from the landfill. If simulations provide a reasonable match to observations, the model will be fine-tuned by calibrating to the observations. If not, we will examine the modeling assumptions and monitoring data to find an explanation for the discrepancy.

The final task (subtasks 6 and 7) is to use the numerical model of the landfill, checked and/or calibrated with monitoring data, to examine sensitivity of flux past the cover to a variety of factors. The first sensitivity tests will be to the primary uncertainties in the landfill model itself, to assess the reliability of the model predictions in a general way. Second, we will conduct a

series of numerical experiments to evaluate how infiltration through the cover might respond to possible changes in the primary climatic variables – temperature and precipitation, vegetation type and rooting depth. Examples of the types of experiments that will be conducted include an increase in precipitation, a change to deeper-rooted vegetation, or complete vegetation removal (as, for example, by fire) and regrowth. The specific experiments performed will be based, in part, on the flux through the cover under existing conditions and will be determined after that task is complete. At the conclusion of these experiments, we will prepare a report that summarizes the modeling effort and, where appropriate, provides recommendations for modifications to the landfill cover and/or for further study.

Please call me at 208-526-6442 with any questions.

Sincerely,

RMShaw

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